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Abandoning Coffee under the Threat of Violence and the Presence of Illicit Crops. Evidence from Colombia[♣].

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Abstract

This paper explores the importance of the risk of violence on the decision making of rural households, using a unique panel data set for Colombian coffee-growers. We identify two channels. First, we examine the direct impact of conflict on agricultural production through the change in the percentage of the farm allocated to coffee. Second, we explore how conflict generates incentives to substitute from legal agricultural production to illegal crops. Following Dercon and Christiaensen (2011), we develop a dynamic consumption model where economic risk and the risk of violence are explicitly included. Theoretical results are tested using a parametric and semi-parametric approach. We find a significant negative effect of the risk of violence and the presence of illegal crops on the decision to continue coffee production and on the percentage of the farm allocated to coffee. Results are robust after controlling for endogeneity bias and after relaxing the normality assumption.

Keywords: selection model, armed conflict, illicit crop, coffee production.
JEL-codes: C21, C34, D13, D74.

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1. Introduction

Recent research in economics shows that violent conflict hinders economic development (Blattman & Miguel, 2010). Attacks deteriorate human capital, damages infrastructure and destroy households' productive assets, imposing direct economic costs on the population (Akresh, Verwimp, & Bundervoet, 2011; Camacho, 2008; Ibáñez & Moya, 2010; Stewart & Fitzgerald, 2001). However, the economic costs of violence go beyond direct victimization by modifying the political, economic and social context in which households operate (Kalyvas, 2006). Violent contexts generate uncertainty, change relative prices and promote institutional changes (Blattman & Miguel, 2010; Tilly, 1992).

Households modify their consumption and production decisions in order to prevent or mitigate the impacts of conflict (Blattman & Miguel, 2010; Brück, 2004; Justino, 2006). The threat of violence or the anticipation to violent shocks oblige rural households to revert to subsistence agriculture and shift portfolio to less risky, but also less profitable activities (Collier, 1999; Deininger, 2003; Morduch, 1995; Nillesen & Verwimp, 2009). Changes in prices and in the institutional context may increase the returns to participation in illegal activities. This generates incentives for households to switch from traditional agricultural activities to illicit crop cultivation. The warring factions involved in the conflict generally support themselves by the latter. Evidence for Afghanistan and Colombia shows that illicit crops such as opium and coca are important sources of money for illegal groups (Mejía & Rico, 2010; Rubin, 2000). Despite large short-term benefits from the cultivation of illegal crops for households, the long-term costs for economic development may be large. The presence of illegal activities intensifies criminal violence, weakens the judicial system and becomes an obstacle to end the conflict (Angrist & Kugler, 2008; Gaviria, 2000).

Identifying the channels through which violence influences household decisions is important to design policies that eliminate or mitigate the consequences of conflict. During post-conflict periods, this evidence is crucial to design policies to reduce the costs of conflict, to boost legal production, and to eliminate the incentives for participation in illegal markets. Most of the economic literature estimates the aggregate costs of violence (Collier & Hoeffler, 2004; Collier, Hoeffler, & Söderdom, 2004; Hoeffler & Reynal-Querol, 2003; Stewart, 2004). The impact on household welfare and production decisions however is largely under-researched despite the recent surge in the collection of micro-level data in conflict-affected countries (Justino, 2009).

This paper explores the importance of the risk of violence due to internal conflict and the presence of illicit crops on agricultural decisions of rural households in Colombia. Building on Dercon and Christiaensen (2011), we develop a dynamic model where economic risk and the risk of violence are explicitly included and whereby producers decide the percentage of land allocated to an export, subsistence or illicit crop. Theoretical results are tested using parametric and semi-parametric sample selection approaches. We use a unique panel data set of coffee-growers built from the Census of Coffee Growers collected between 1993 and 1997 - abbreviated as CCS93/97 - and the Coffee National Information System - SICA[1] (2008). We identify two channels. *First*, we examine the direct impact of conflict on agricultural production through the change in the percentage of the farm allocated to coffee. *Second*, we explore how conflict generates incentives to substitute legal agricultural production for illegal crops using the farmers that dropped out between two censuses. Both channels ultimately reduce legal agricultural production.

Evidence on the economic decisions of farmers operating in conflict regions is scarce. Some noteworthy exceptions are Brück (2004), Nillesen and Verwimp (2010) and Rockmore (2011), yet these papers use small panel data sets for rural farmers in Mozambique and Burundi respectively, and cross-sectional data for Uganda. Little is known about how conflict generates incentives to produce illegal crops. Studies are mostly based on aggregate data (Dube & Vargas, 2013 ; Moreno-Sanchez, Kraybill, & Thompson, 2003; Rubin, 2000) or measure the indirect effect of coca presence on economic and labor outcomes (Angrist & Kugler, 2008). The contribution of our paper is twofold. *First*, the paper provides evidence on the microeconomic costs of conflict using a unique panel data set on coffee production in Colombia, the country's main export crop. *Second*, the paper shows how conflict modifies the returns to illegal crops, inviting substitution of export for illegal crops.

[1] Spanish Acronyms. Sistema de Información Cafetero –SICA-

The identification strategy combines farm and municipality level information to exploit the variation over time and space of violence and illegal crops. By using the parametric and semi-parametric Heckit estimator, we attempt to eliminate any bias from unobserved household characteristics in the participation and allocation equation. In addition, we use instrumental variables to reduce any additional bias from the occurrence of violence and of illegal crops in the selection equation. We estimate the just-identified model using two instruments: i) the former territories occupied by Spain (1510-1561) that where the object of land conflict in the period 1881-1931 to instrument for violence; and, ii) the size of the land covered by rainforest to instrument for the presence of illegal crops. We demonstrate the relevance of these instruments.

We find a significant impact of the risk of violence and the presence of illegal crops in the decision to continue the cultivation of coffee and in the percentage of the farm allocated to coffee. Results are robust after controlling for endogeneity bias in the selection equation. In line with our theoretical model, we find that coffee growers are more likely to drop-out of coffee when they are exposed to high risk of violence and the presence of illegal crops. After relaxing the distributional assumption in the full-parameterized Heckit, we obtain similar results.

The structure of the paper is as follows. Section two discusses briefly the recent economic literature on the impact of shocks on production decisions, introducing the theoretical model and the main hypotheses of the paper. Section three introduces empirical evidence form coffee growers, conflict and illicit crops in Colombia. Section four describes the data and our estimation strategy. The econometric results are discussed in section five. Section six concludes.

2. Agricultural production, economic risk and the risk of violence

Agricultural producers are exposed to several risks such as variations in climatic conditions, crop diseases and natural disasters, among others. Exposure to and incidence of these risks reduces welfare and leads to inefficient production (Janvry & Sadoulet, 2006; Roe & Graham-Tomasi, 1986; Rosenzweig & Binswanger, 1993). Furthermore, because agricultural producers face market imperfections, limited access to formal lending and incomplete insurance, risk in production affects consumption

(Dercon, 1996; Dercon & Christiaensen, 2011; Janvry & Sadoulet, 2006; Roe & Graham-Tomasi, 1986).

Households modify production decisions in order to protect consumption from the incidence of shocks. They change asset composition towards assets less sensible to particular risks or which can be easily converted to cash, but which are also less profitable (Dercon, 1996; Fafchamps, Udry, & Czukas, 1998; Janvry & Sadoulet, 2006; Rosenzweig & Binswanger, 1993). Risk may also deter producers from irreversible investments that would increase productivity, yet cannot be easily converted to cash during shocks as well as from using risky inputs (Dercon & Christiaensen, 2011; Roe & Graham-Tomasi, 1986). Besides changing investment or input decisions, households adjust production decisions favoring less risky crops, subsistence production, or activities that generate cash (Dercon & Christiaensen, 2011; Janvry & Sadoulet, 2006). Diversifying income sources, by for example allocating time to off-farm activities, is an additional strategy to reduce risks (Barrett, Reardon, & Webb, 2001; Dercon, 1996; Ito & Kurosaki, 2009; Janvry & Sadoulet, 2006; Kochar, 1999; Roe & Graham-Tomasi, 1986)

Spatially covariant risks are more likely to reduce welfare, while empirical evidence show households are able to insure against idiosyncratic risks. As covariant shocks reduce(Dercon & Ayalew, 1995) mean community income, insurance arrangements are difficult to design and loans are often unavailable. Thus, households with a high likelihood of facing covariant risk adopt *ex ante* strategies such as the ones described above (Alderman & Paxson, 1994; Rosenzweig & Binswanger, 1993). However, richer households need to engage less in *ex ante* risk management as assets stocks and access to financial markets allow them to better handle *ex post* shocks (Dercon & Christiaensen, 2011; Janvry & Sadoulet, 2006; Rosenzweig & Binswanger, 1993).

In conflict-affected regions, rural households face, in addition, shocks of violence. Violence affects production through different channels. *First*, attacks, extortions or crop and livestock seizure reduce production, destroy assets and deteriorate human capital (Deininger, 2003; Justino, 2012). *Second* is the impact on labor supply. The heightened sense of insecurity and direct attacks on the civil population generates forced displacement, while recruitment of combatants and illegal crops compete with agricultural labor (Dube & Vargas, 2013 ; Fernández, Ibáñez, & Peña, 2011). *Third*, even when households are not directly attacked, violence destroys infrastructure, decreases the provision of public goods, limits the presence of financial intermediaries, and increases transaction costs; thereby, reducing agricultural income and increasing costs (Deininger, 2003; Justino, 2012). Lastly, by creating uncertainty and modifying returns to agricultural production, violence changes the incentives to agricultural producers (Rockmore, 2011).

Farmers modify their behavior to protect their welfare levels in anticipation of or in response to a violent shock (Blattman & Miguel, 2010; Justino, 2009). Despite *ex-ante* mechanisms, the dynamics of civil conflict may push households to recur to other strategies that may protect them from victimization, yet reduce agricultural production further. In order to avoid attacks, wealthier households may want to (Bellows & Miguel, 2009; Engel & Ibáñez, 2007; Verwimp, 2003b), become less visible in the community, retrieve from markets, reduce the size of trading networks and invest in assets that are not easily detected (Deininger, 2003). For example, farmers may prefer financial assets instead of investments in agricultural equipment, and livestock. Households may also reduce investments in location-specific assets, such as land or irrigation, or simply postpone investments leaving land idle. The contribution of off-farm activities to diversify income as an *ex ante* management strategy or as an *ex post* alternative to compensate for income drops is an open question. On the one hand, markets in conflict region may break down contracting labor demand. On the other, new labor opportunities, such as illegal activities or participation in armed groups, may emerge in conflict regions.

Empirical evidence on the changes in production and investment decisions caused by violence in conflict regions is largely absent. Economic research has found that the threat or anticipation of future shocks, like violence, pushes rural household to revert back to subsistence agriculture and shift portfolio to less risky, but also less profitable activities (Deininger, 2003; Nillesen & Verwimp, 2010). Rural households also increase participation in informal credit markets and recur to precautionary savings (Binzel & Brück, 2007; Brück, 2004). Other studies have also shown that a decrease of agricultural prices may fuel further violence in regions where conflict is present. Drops in agricultural prices reduce agricultural wages and returns, creating incentives for participation in armed groups and production of illicit crops (Dube &

Vargas, 2013 ; Moreno-Sanchez et al., 2003). In addition, illegal crop cultivation may perpetuate the conflict by providing monetary resources (Angrist & Kugler, 2008).

2.1. A Theoretical model of farm allocation under economic risk and the risk of violence

The purpose of the model is to understand how exogenous risk influences the decisions of farmers and creates incentives for the production of illegal crops. In the model, farmers select the percentage of land allocated to each crop in order to maximize their utility derived from consumption, and reduce economic risk and the risk of violence over time. We assume farmers do not have access to financial or insurance markets and production of each crop is technically independent or non-joint with non-labor markets. Because alternatives for *ex-post* consumption smoothing are non-existent, farmers select land allocation among the three crops to protect consumption from economic and violent shocks. This model captures the two purposes of our paper: identify how conflict affects production of export and illegal crops. The model builds on Dercon (1996) and Dercon and Christiaensen (2011).

Farmers face two correlated risks: economic (ε_t) and violent (φ_t). Economic risks stem from price variations, weather conditions and natural shocks, among others, that affect yields. It is assumed as random, serially uncorrelated and realized after allocation decisions have been made (Dercon & Christiaensen, 2011). In contrast, risks of violence arise from the exogenous uncertainty brought by living in a conflict region, and is generated by a bivariate distribution whereby a peaceful state is represented by $\varphi_t = 0$ and a violent state by $\varphi_t = 1$. We assume that this state is known at the beginning of each period before allocation decisions are made.

Farmers select the optimal allocation of land available for agricultural production (L) on three crops – risk-free, export and illegal crops - based on returns for each crop. Let s_t be the proportion of the farm allocated to the risk-free crop in period *t* with known return per unit of land allocated ($\bar{\pi}_1$); the expected return is given by $s_t L \bar{\pi}_1$.

The proportion of land allocated to the export crop in period *t* is represented by z_t, where economic risk and the risk of violence determine gross returns per unit of land allocated $\pi_2(\varepsilon_t|\varphi_t)$. Lower returns for the export crop in a violent state arise from several direct and indirect impacts of conflict such as those described in the previous section, *ceteris paribus:* $\forall\varepsilon_t: \pi_2(\varepsilon_t|\varphi_t = 1) < \pi_2(\varepsilon_t|\varphi_t = 0)$. Gross returns decrease with high economic risk, $\frac{\partial\pi_2(\varepsilon_t|\varphi_t)}{\partial\varepsilon_t} < 0$. The expected return is given by $z_t L\pi_2(\varepsilon_t|\varphi_t)$.

Now, let n_t be the proportion of land in illegal crops in period *t*. We assume, without loss of generality, economic risks do not influence the returns of the illegal crop. Several features of coca markets in Colombia validate this assumption, in particular, in violent state ($\varphi_t = 1$). Armed groups and cocaine traffickers minimize economic risks by providing technical assistance, a minimum price, and collection of yield at the farm gate[2]. Coca trees are, in addition, an easy crop to grow as, once planted, the bush produces each year with a minimum of maintenance (Moreno-Sanchez et al., 2003). Thereby the gross return per unit of land allocated is represented by $\pi_3(\varphi_t)$. In contrast to the export crop, moving from a peaceful to a violent state increases the returns to growing the illegal crop $\left(\pi_3(\varphi_t = 1) > \pi_3(\varphi_t = 0)\right)$. The support of armed groups to promote illegal crop cultivation, lack of state presence, and the breakdown of the rule of law determine the higher returns of illegal crops under a violent state. Thus the expected return is denoted by $n_t L\pi_3(\varphi_t)$.

Moreover, those farmers who decide to grow the illegal crop could be caught and face a financial punishment. Although we only consider the economical penalty, policies against illegal crop could also include: jail or land expropriation, among others (Mejía & Rico, 2010). We assume the punishment as a given proportion of the assets (θA_t) that is determined by law. Therefore, farmers will be willing to grow illegal crops if and only if the expected return is larger or equal to the punishment

$$n_t L\pi_3(\varphi_t) \geq \theta A_t \qquad (1)$$

We assume that the return to the illegal crop in a violent state yields the maximum return for the farmer. It is assumed that $\bar{\pi}_1 > \min[\pi_2(\varepsilon_t|\varphi_t)] \geq 0$ and $\bar{\pi}_1 > min[\pi_3(\varphi_t)] \geq 0$, i.e. the lowest gross return for the risky crops are non-negative but lower than the risk-free crop. Assume that the household maximizes the

[2] Interview with a demobilized high-rank member of FARC, July 2010.

expected flow of standard intertemporally additive utility from consumption: $u_t = \sum_{\tau=t}^{T}(1+\delta)^{t-\tau}E_{t-\tau}v(c_t)$; with $v(.)$ instantaneous utility derived from consumption c_t and $v'(.) > 0$, $v''(.) < 0$, and δ the rate of time preference. Now, let r be the rate of return of saving between periods. Therefore, assets evolve from one period to the next according to

$$A_{t+1} = (1+r)(A_t + s_t L\bar{\pi}_1 + z_t L\pi_2(\varepsilon_t|\varphi_t) + n_t L\pi_3(\varphi_t) + m_t - c_t) \quad (2)$$

where, $s_t + z_t + n_t = 1$ and m_t is an external financial support. Following Dercon and Christiaensen (2011), we assume that assets can be liquidated at any point in time. Consumption prices are used as the numeraire. Consumption is decided after income has been generated from production and after the punishment has been implemented, in case that the farmer was caught. Thus the value function at period t, is given by

$$V_t(A_t) = \max_{c_t, z_t, n_t} E_t\Big[v(c_t) + \frac{1}{1+\delta}V_{t+1}((1-r)(A_t + z_t L(\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1) + n_t L(\pi_3(\varphi_t) - \bar{\pi}_1) + m_t - c_t) + \gamma_t(A_t + z_t L(\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1) + n_t L(\pi_3(\varphi_t) - \bar{\pi}_1) + m_t - c_t) + \lambda_t\Big(A_t - \frac{n_t L\pi_3(\varphi_t)}{\theta}\Big)\Big] \quad (3)$$

To solve this problem, we first derive the optimal consumption rule after uncertainty over income has been resolved

$$\frac{\partial V_t(A_t)}{\partial c_t} = v'(c_t) - E_t\Big[\frac{(1-r)}{(1-\delta)}.V'_{t+1}(A_{t+1}) + \gamma_t\Big] = 0 \quad (4)$$

Now, to obtain the optimal allocation rule we need to take the derivative of Eq. (3) with respect to each crop at the beginning of the period, where the risk of violence is already known from the last period but economic risk is unknown (i.e. before uncertainty has been resolved), that is

$$\frac{\partial V_t(A_t)}{\partial z_t} = E_t\Big[\Big(\frac{(1-r)}{(1-\delta)}.V'_{t+1}(A_{t+1}) + \gamma_t\Big)(\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1)\Big] = 0 \quad (5a)$$

$$\frac{\partial V_t(A_t)}{\partial n_t} = E_t\Big[\Big(\frac{(1-r)}{(1-\delta)}.V'_{t+1}(A_{t+1}) + \gamma_t\Big)(\pi_3(\varphi_t) - \bar{\pi}_1)\Big] - \lambda_t\frac{\pi_3(\varphi_t)}{\theta} = 0 \quad (5b)$$

Expanding Eq. (5a):

$$\frac{\partial V_t(A_t)}{\partial z_t} = E_t\left[\left(\frac{(1-r)}{(1-\delta)}.V'_{t+1}(A_{t+1}) + \gamma_t\right)\right]E_t[(\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1)] + cov\left[\left(\frac{(1-r)}{(1-\delta)}.V'_{t+1}(A_{t+1}) + \gamma_t\right), (\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1)\right]$$

Now, since ε_t and ε_{t+1} are uncorrelated[3] and given Eq. (4):

$$cov\left[\left(\frac{(1-r)}{(1-\delta)}.V'_{t+1}(A_{t+1}) + \gamma_t\right), (\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1)\right] = cov\left[E_t\left(\frac{(1-r)}{(1-\delta)}.V'_{t+1}(A_{t+1}) + \gamma_t\right), (\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1)\right] = cov[v'(c_t), (\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1)]$$

Therefore, Eq. (5a) could be re-written as:

$$\frac{\partial V_t(A_t)}{\partial z_t} = E_t[v'(c_t)]E_t[(\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1)] + cov[v'(c_t), (\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1)] = 0$$

Or, equivalently

$$\frac{\partial V_t(A_t)}{\partial z_t} = E_t[v'(c_t)(\pi_2(\varepsilon_t|\varphi_t) - \bar{\pi}_1)] = 0 \qquad (6)$$

Analogously, we rewrite Eq. (5b) as follow:

$$\frac{\partial V_t(A_t)}{\partial n_t} = E_t[v'(c_t)]E_t\left[\left((\pi_3(\varphi_t) - \bar{\pi}_1)\right)\right] + cov\left[v'(c_t), \left((\pi_3(\varphi_t) - \bar{\pi}_1)\right)\right] - \lambda_t\frac{\pi_3(\varphi_t)}{\theta} = 0$$

Or,

$$\frac{\partial V_t(A_t)}{\partial n_t} = E_t[v'(c_t)(\pi_3(\varphi_t) - \bar{\pi}_1)] - \lambda_t\frac{\pi_3(\varphi_t)}{\theta} = 0 \qquad (7)$$

As we do not specify a particular form for the utility function nor for the gross return functions, we do not provide a closed solution of the inter-temporal optimal allocation rule. Eq. (6) and (7) do provide important information to help us identify whether or not the choice among crops is determined by an *'ex ante'* violent state or by *'ex post'* economic risk.

Consider a first scenario where farmers realize that they face a peaceful state ($\forall\varepsilon_t: \varphi_t = 0$) at the beginning of the period; hence they only face an *'ex post'* economic risk through the return to the export crop. When the punishment restriction is binding ($\lambda_t \gg 0$), which is always the case in the peaceful state, the expected return on the illegal crop reaches the lowest value, and, therefore, farmers prefer to concentrate on the export and risk-free crops.

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[3] It implies that $E_t\left[cov\left[\left(\frac{(1-r)}{(1-\delta)}.V'_{t+1}(A_{t+1}) + \gamma_t\right), (\pi_3(\varphi_t) - \bar{\pi}_1)\right]\right] = 0.$

Because farmers are assumed risk averse, the land allocation rule will be determined by $(\pi_2(\varepsilon_t|\varphi_t = 0) - \bar{\pi}_1)$ (see Eq. 6). If, in addition, they face an economic risk, the marginal utility of a risk-free yet low yielding crop will have a higher weight in the value of Eq. (4) than the risky alternatives. This implies that farmers prefer the safest activity (i.e. with higher marginal returns) when economic risks are high (Dercon & Christiaensen, 2011). Thereby, under high economic risk (e.g. price volatility), a first corner solution is feasible. Farmers will drop out of the export crop even in a peaceful state, allocating all the land to the risk-free crop.

Now, consider a second scenario where farmers realize that they face a violent state $(\forall\varepsilon_t: \varphi_t = 0)$ at the beginning of the period, in addition to the *'ex post'* economic risk. Because violent and economic risks are correlated, the expected return for the export crop decreases for any value of ε_t. As we pointed out above, since the farmers are assumed risk averse they always prefer to allocate some proportion of the land to the risk-free crop. To see that in detail, observe that if the consumption constraint is binding $(\gamma_t > 0)$ the marginal utility of consumption increases and the marginal expected return to the risky crop decreases (see the covariance in Eq. (6) and (7)). In contrast, if farmers can smooth consumption $(\forall\varepsilon_t: \gamma_t = 0 \wedge \lambda_t \geq 0)$, the covariance between marginal return and marginal utility is zero, farmers will behave as risk-neutral (Dercon & Christiaensen, 2011). This fact is particularly interesting when the role of external financial support (m_t) is taken into account: relaxing the binding constraint will boost, for instance, export crops. Moreover, a high initial asset stock, allows farmers to invest a higher proportion of land in the crop that has the highest risks. In contrast, households with a low stock of assets specialize in the low-risk low return activity.

Even though an interior solution is feasible, there exist two corner solutions in a violent state. On the one hand, if the punishment constraint is still binding $(\lambda_t > 0)$ and the economic risk is high, a state of violence pushes the farmer to allocate all the land to the risk-free crop, that is, farmers are pushed to revert back to subsistence agriculture (Deininger, 2003; Nillesen & Verwimp, 2010). On the other hand, if the punishment constraint does not bind $(\lambda_t = 0)$ or, equivalently, the expected return of the illegal crop is much larger than the punishment $(n_t L\pi_3(\varphi_t) \gg \theta A_t)$, farmers will have enough incentive to abandon export crop cultivation and allocate the land between the risk-free and the illegal crop.

Table 1 summarizes the possible solutions in the model. We are particularly interested in the corner solution. We can identify two types of corner solutions. *Firstly*, a risk adverse farmer pushed to allocate the entire farm to a risk-free crop in response to increased economic risk or risk of violence. We call this solution *'subsistence dropping out'*. *Secondly*, in the violent state, farmers deciding to drop the export crop due to either high economic risk or high expected return for the illegal crop. We call this solution *'Illegal dropping out'*. Other solutions that involve a non-zero allocation of the land to an export crop are called *'Interior solution'*.

[Table 1 goes about here]

3. Colombian Coffee growers under the threat of conflict and illicit crops.

Climate conditions, economic policies, institutional dynamics and soaring coffee prices at the beginning of the 20th century generated a favorable environment for the emergence and consolidation of coffee as the main export product of Colombia during most of the 20th Century (Bejarano, 1996). The creation of the National Federation of Coffee Growers (FNC-by its Spanish acronym) in 1927 and of the price stabilization fund in 1929 further strengthened this process and provided support for the expansion of coffee in many Colombian regions. The price stabilization fund purchase coffee production from growers at a price that is regarded as fair, calculated using international prices. Coffee is bought by the FNC through 36 cooperatives that are located in 511 agencies throughout the country. Besides guaranteeing a minimum price, the FNC provides support to coffee growers such as technical assistance, transfer of technological innovation, credit, infrastructure, social protection, health services, and education programs, among others. Officials of the FNC are democratically elected within each State Committee. The support provided by the FNC was crucial to consolidate coffee as the main export product during the 20th Century, and promote economic development in coffee regions.

Parallel to this process, a dormant conflict named *La Violencia* erupted in 1948.

Since its independence from Spanish rule in the 19th Century, Colombia has faced several civil conflicts. Although a confrontation between the two major political parties was the main cause of *La Violencia*, local conflicts linked to land disputes fueled the violence in many regions (Roldán, 2002). The strong presence of the FNC in the coffee regions and the support to coffee growers provided a safe haven that isolated these areas from the conflict ravaging other regions (Oquist, 1980; Palacios, 1980). In 1953, a power-sharing agreement ended the conflict, but local conflicts and land disputes remained unresolved in most regions of the country.

Technological innovations and a spike in prices during the 1970s increased coffee production in Colombia. However, a plague and a renewed expansion of Brazilian production forced some Colombian producers to opt out of coffee. The FNC implemented an aggressive policy to promote the adoption of modified crops that were more resistant to plagues and weather conditions.

Meanwhile, the conflict subsided with the emergence, at the end of the 1960s, of left-wing guerrilla groups. The original purpose of the guerrilla groups was to seize power.[4] Yet their activities were located in isolated regions of the country. The emergence of drug traffickers fueled the conflict by providing resources to fund guerrilla groups and instigating the creation of right wing paramilitary groups to defend some landowners and drug dealers from guerrilla attacks. The policies implemented in Peru to halt coca production in 1994 generated further incentives for coca production. Conflict regions became ideal scenarios for the expansion of illicit crops' cultivation. All these intensified the conflict and consolidated its geographic expansion.

The end of the international quota agreement, that had stabilized prices at high levels, changed coffee markets. Prices fell substantially and large fluctuations, previously unknown to coffee growers, became frequent. Many producers had to diversify to other agricultural products, to opt-out of coffee or to abandon their land (CRECE, 2002; Muñoz-Mora, 2010). In 2001, prices fell to the lowest levels in 180 years deteriorating even more the conditions of coffee producers. In addition, the two crisis of international coffee prices contracted the FNC resources, which limited its

[4]The most important guerrilla groups still active today are: The Revolutionary Armed Forces of Colombia FARC and National Liberation Army ELN

capacity to implement programs to ease the consequences of the crisis on coffee growers (CAIC, 2002).

Consequently, traditional coffee regions, which had been historically isolated from the conflict, were exposed to risks, such as violence and the presence of illicit crops (Dube & Vargas, 2013 ; Muñoz-Mora, 2010; Rettberg, 2010). Illegal groups strengthened their presence in coffee regions and intensified violence against the civilian population. In 1985, guerrilla groups were present in respectively 15 and 2 per cent of non-coffee and coffee growing municipalities, while in 1995, these figures increased to 58 and 53 per cent, respectively (Bejarano, 1992). Attacks against the civilian population also increased: during the period between 1990 and 2008, coffee municipalities faced 2.63 attacks per year from illicit groups and non-coffee municipalities 1.94.

Graphs 1 and 2 show the evolution of homicide rates and forced displacement for the period between 1993 and 2008. We compare the evolution for three groups of municipalities: (i) municipalities traditionally dedicated to coffee production; (ii) municipalities that recently started coffee production; and (iii) municipalities that are not coffee producers[5]. In 1993, homicide rates were significantly higher for traditional coffee regions, while non-coffee producers experienced lower homicides rates. From 2001 onwards, traditional coffee regions experienced a sharp drop in homicide rates and in 2008 homicide rates for the three groups of municipalities were similar. The dynamics of forced displacement, which show aggressions of armed groups against civilians, indicate a similar pattern. Forced migration has been consistently higher for traditional coffee regions and non-coffee regions. However, reductions in forced displacement have been steeper for traditional coffee region and in the year 2008 the number of forcefully displaced was significantly lower for these municipalities. Thus, despite an increasing presence of armed groups in coffee regions, aggressions of armed groups are lower than in other regions. Nonetheless, criminal violence, represented by homicide rates, is similar.

[Graph 1 and 2 go about here]

[5] We use information from 1970 and 1980 to categorize traditional coffee municipalities.

Interestingly, the trend for coca production exhibits a different pattern than homicide rates and forced displacement. As Graph 3 shows, in contrast to traditional coffee regions, the percentage of land cultivated in coca (hectares) with respect to the area of the municipality in 1993 was 14 times larger in non-coffee regions and threefold for non-traditional ones. While coca production has decreased in non-coffee regions, coca production in traditional coffee regions has steadily increased. In spite of the increasing trend, the percentage of coca production in non-coffee regions is threefold that of traditional coffee regions. The growing trend of coca cultivation in traditional coffee regions started in 2002, a year after the coffee crisis in 2001, which may have prompted some coffee growers to shift from coffee production to coca cultivation.

[Graph 3 goes about here]

Deteriorating market conditions, aggressions against the civilian population and the emergence of coca production may seemingly influence the decisions of coffee growers. Despite of the strong support provided by the FNC, conflict and coca presence presumably modified the returns of coffee production, and provided in some regions an attractive alternative to dwindling market conditions: coca production. Next section presents the data and the empirical approach based on the theoretical hypotheses.

4. Data and estimation strategy

We use two unique data sources: The Census of Coffee Growers (CCG93/97) and the National Coffee Information System of 2008 (SICA for its Spanish acronym), which were collected by FNC. As a planning tool, the FNC has carried out coffee censuses in 1970, 1980 and 1993-1997. The purpose of the coffee censuses is to collect information on coffee production, and the on physical characteristics of each land plot. A questionnaire is fielded to each coffee grower to collect information on land plot size, the size of the land allocated to coffee production and other crops (in hectares), and physical characteristics of the coffee trees (e.g. number, age, seed type). The CCG93/97 administered the census to 663.539 coffee growers in 559 municipalities between 1993 and 1997. This last census also gathers sociodemographic information for a random sub-sample of producers. Although a new census was not administered, the FNC designed the SICA to update all production information of the CCG93/97. The system is updated when coffee growers request any type of support from the FNC. Since each coffee grower has an identification number provided by the FNC, we are able to match the census and SICA information. The SICA in 2008 has information on 75.5 percent of the coffee growers included in the CCG93/97 censuses located in 552 municipalities, which correspond to 93.2 percent of the CCG93/97 municipalities. From the original municipalities, seven (1.3 percent) abandoned coffee production during this period.

Two reasons may explain attrition from the SICA information system. *First*, some coffee growers may have stopped requesting the support of the FNC. This possibility is unlikely as the support of the FNC provides benefits to coffee growers, while the costs represented by the coffee tax has to be paid regardless of the FNC support. *Second*, some coffee growers may have abandoned coffee production and switched to other activities. Drops in coffee prices, the intensification of conflict, the emergence of coca production, and urbanization are some of the potential causes for dropping out of coffee production. The latter is not a random process and is determined by decisions of coffee growers as well as by municipality characteristics. Map 1 shows the percentage of coffee growers that dropped out and that continued coffee production between 1993 and 2008. We observe that municipalities that abandoned coffee production altogether are not geographically clustered. This may imply that municipal dynamics played a lesser role in stopping coffee production. In the Appendix we estimate a municipal-level regression of dropping out of coffee and we do no find statistically significant results for the coefficients of attacks by armed groups and the presence of coca. We conclude that there is a not systematic selection rule at the municipality level.

[Map 1 goes about here]

Since neither CCG93/97 nor SICA collect victimization information at the household level, we use aggregated municipality level data. The effect can only be observed at this level. The channel through which such covariate shock affects a single person or household remains unobserved (Imbens & Lancaster, 1994). We use the sum of all military actions of warring factions (by 100 people) against the civilian population as well as the average area under coca cultivation (in % of land size) as proxies for violence and for illegal crops respectively.

An additional issue is the period between our two micro-data sources. We use the overall average as proxy of the exposure to violence and to illegal crops. Several elements strengthen this decision: (1) the mean is increasing across the number of years of exposure; (2) less exposed municipalities are symmetrically distributed over the periods, in particular, between 1997 and 2002. Therefore, even though we cannot separately identify the effect of duration and intensity, nor the specific effect of the soaring of violence, the average provides a very useful measure of exposure.[6] Besides we include municipality-level controls for land, market conditions and FNC support. The data come from the database built by Centro de Estudios del Desarrollo – CEDE at Universidad de los Andes-Colombia.

4.1. Estimation strategy

The aim of the empirical analysis is to analyze the impact of exposure to violence and illegal crops on the allocation of land by Colombian coffee growers. In line with our theoretical model, we have identified that an optimal allocation rule could take into account several corner and interior solutions that are determined by the level of exposure to economic risk and the risk of violence. We estimate the coffee crop allocation rule in 2008 controlling for potential sample selectivity. Let z_i^* be the linear optimal allocation function for the export crop in period t, which is censored at 0 due to corner solutions. Hence in period t, we only observe those farmers that have a positive percentage of their farm allocated to coffee (z_i) as a result of the selection mechanism (d_i). That is,

$$z_i^* = \boldsymbol{x}_i'\beta + \epsilon_i \tag{8a}$$

$$d_i^* = \boldsymbol{h}_i'\gamma + \upsilon_i \tag{8b}$$

$$z_i = z_i^*.d_i \text{ , where, } d_i = \begin{cases} 1 & if \quad d_i^* > 0 \\ 0 & otherwise \end{cases} \tag{8c}$$

[6] The appendix provides additional statistical evidence.

where $\boldsymbol{x_i}$ and $\boldsymbol{h_i}$ are vectors of exogenous variables. Furthermore, ϵ_i and υ_i are zero mean errors with $E[\epsilon_i|\upsilon_i] \neq 0$. This model, known as Type II-Tobit, provides an explicit form for the sample selection bias and presents an alternative to the OLS estimator recovering the consistency of the estimates (Amemiya, 1985) . We use the two-step Heckit estimator. This parametric estimator provides an intuitive way to deal with sample selection based on the *control function approach*, imposing a parametric correction through the generalization of the Probit residual known as Inverse Ratio Mill Ratio (IMR)[7] (Gouriéroux, 1991; Heckman, 1978, 1979). The Heckit estimator requires two important assumptions: the joint normal distribution for ϵ_i and υ_i, which makes the control function approach feasible; and an identification requirement that requires the inclusion of at least one variable in the first step (Eq. (8b)) that is excluded in the second step (Eq. (8c))[8].

As the estimation heavily relies on the normality assumption, the estimates are inconsistent if normality fails. There are several free-distribution estimators proposed as an alternative to the full parametric Heckit. The most popular semi- and non-parametric estimators follow the same two-step structure. We use the semi-parametric estimator proposed by Ahn and Powell (1993). The idea behind it is very intuitive: the authors showed that if two observations *i* and *j* have similar values for a single index generated by a non-parametric kernel regression, then it is likely that subtracting both observations will eliminate the selection bias without imposing any distributional assumption (Ahn & Powell, 1993; Newey, 2009)[9].

We estimate the selection or participation equation described by Eq. (8b), to capture coffee growers in CCG93/97 census that continued coffee production in SICA (2008). The probability to continue coffee production in 2008 for a household *i* that was active in CCG93/97 residing in municipality *j* is represented by

$$d_{ij}^*(z_{ij} > 0) = \gamma_1 + \gamma_2\varphi_j + \gamma_3 n_j + \boldsymbol{ex'_j}\boldsymbol{\gamma_4} + \boldsymbol{x'_i}\boldsymbol{\gamma_5} + \boldsymbol{m'_j}\boldsymbol{\gamma_6} + \upsilon_i \quad (9)$$

[7] For a survey of two-step parametric Heckit see Vella (1998), Lee (2008) and Puhani (2000). For semi- and non-parametric estimators see Newey (2009) and Newey, Powel and Walker (1990).
[8] This 'exclusion restriction' has widely been criticized because there are frequently few candidates and is possible to have nonlinearity in the inverse Mills ratio that makes such restriction unnecessary (Manski, 1989; Vella, 1998). Nevertheless, in a semi and no parametric context it is compulsory (Newey, 2009).
[9] More details are in the Appendix.

where φ_j captures violent shocks at the municipality level defined by the average of Military Action of illegal groups against the civilian population between (1998-2008) per 100 people. As we are not able to observe the percentage of land allocated to coca production at the household level (n_i), we use an indirect approach to examine how the conflict may create incentives to substitute coffee for coca. We include the percentage of municipal hectares allocated to coca production, which captures the aggregated decisions to shift to coca production (n_j).

$\boldsymbol{ex_j}$ represents the exclusion restriction vector. We use a natural experiment of selection prompted by the earthquake in the coffee region in 1999. In particular, we use the percentage of the population by municipality that lost their house and those who suffered personal damage such as injures or death. Two observations support this choice. First, the traditional coffee region was in the epicenter of the earthquake. Second, even though policies from both Government and FNC where put in place to help coffee growers, the resulting income transfers were transitory and did not constitute a permanent income shocks (CEPAL, 1999). Thereby it is likely that the earthquake affected the participation decision but not the allocation decision[10].

x_i is a vector of initial characteristics of households and land plots from the CCG93/97 census. The vector includes the percentage of land cultivated in coffee, number of coffee trees, the average age of trees, the crop density (number of trees divided by hectares), and the size of the land plot. m_j is a vector of municipality controls, including land quality (UAF)[11] and altitude (meters above sea level). To capture economic shocks, we include the mean of relative prices of coffee with respect to other agricultural goods produced in each region during the period between 1993 and 2008[12]. As some households may have abandoned coffee production due to municipal level dynamics, we control for changes in coffee production in the municipality during both periods. By controlling for this variable, we are estimating the effect of conflict on households' decisions once municipal changes due to conflict

[10] In the appendix we provide more evidence to validate the exclusion restriction.

[11] The *Unidad Agricola Familiar* (UAF, Spanish acronym) is the measurement of the minimum plot size required to earn a minimum wage, defined by the Government of Colombia on the basis of soil characteristics.

[12] In the relative prices index of coffee we use the prices of the main coffee substitute crops (e.g. plantain, yucca, among others) from the nearest market.

and other dynamics are accounted for. We measure institutional support with fixed effects for the presence of a FNC regional committee and with the number of agricultural FNC's technicians present in the region. In addition, we include fixed effects for the four coffee natural regions and the year when the CCG93/97 was carried out. For a subsample of households, we estimate the regressions controlling for variables that capture the life cycle (age of household head, age squared and number of household members between 15 and 65 years of age), gender and education level of the head of the household.

After the estimation of the selection equation we proceed with the truncated allocation equation described by Eq. (8c). Besides pushing households to abandon coffee production, conflict may change the decision on the percentage of the land to allocate to coffee production. Once a farmer decides to continue coffee production, she chooses the number of hectares allocated to coffee production, to a non-risk crop and to coca. Thus, we estimate the percentage of the farm cultivated in coffee in 2008 for household *i* located in municipality *j* defined by

$$z_{ij} = \beta_1 + \beta_2\varphi_j + \beta_3 n_j + \boldsymbol{x}_i'\boldsymbol{\beta}_{\square} + \boldsymbol{x}_i^{*\prime}\boldsymbol{\beta}_6 + \boldsymbol{m}_j'\boldsymbol{\beta}_7 + \upsilon_i \qquad (10)$$

In addition to the controls described above, we include a vector x_i^* that describes the characteristics of the households and the land plot from SICA (2008). In particular, we include the number of coffee trees, the average age of trees, the crop density (number of trees divided by plot size), and the size of the land plot. Hence, joint with x_i we can isolate the effect of initial conditions and other unobserved productive changes.

The selection equation may face a problem of endogeneity. *On the one hand*, empirical observation shows that the presence of armed groups and the attacks against the civilian population are not random. Armed groups seek to strengthen territorial control in regions considered valuable for strategic purposes or political motives. These areas often have potential to extract valuable resources, to provide funds to finance war activities, or proof less costly to establish control (i.e. regions with political grievances, isolated regions, or with difficult geographical terrain). If these variables are correlated with unobserved dynamics that influence coffee production, the coefficient estimates will be biased. Moreover, households are not only affected by the risk of violence, but can also actively participate as soldiers (Blattman & Miguel, 2010; Justino, 2009; Nillesen & Verwimp, 2009; Verwimp, 2003a). *On the other hand*, as the theoretical model shows, the percentage of land allocated to coca production at the municipality level is endogenous to the decision of coffee growers.

To deal with the endogeneity problem, we propose to use a just-identified model using two instruments[13]. *First*, we use the former territories occupied by Spain (1510-1561) that were the object of land conflict in the period 1881-1931 for instrument our violence approach. As we pointed out above, it has been widely shown that grievances related to unequal land tenure determined the initiation of the current conflict in Colombia. Territories where Spanish were initially settled, became later the main production centers and the initial agricultural frontier led to high land concentration (LeGrand, 1988). This variable is exogenous to coffee production because those territories where located along all altitudes, not only in altitudes ideal for coffee production.

Second, we use the size of the land covered by rainforest (in 100000 hectares) toinstrument presence of coca. Although coca production shares similar natural conditions as coffee crops[14], the illegal crop is generally cultivated in isolated regions on the agricultural frontier often covered by rainforest, where climatic conditions are highly suitable and where it is easy to evade the rule of law and (Dávalos et al., 2011). In contrast, coffee is cultivated in open spaces near productive centers with large state presence and low forest cover. The proportion of rainforest in the municipality is exogenous to the coffee crop. This information was built using the land cover and vocation soil studies launched by IGAC (Instituto Geográfico Agustín Codazzi), which is the Colombian institute for geography and cadastral information[15].

[13] In spite of the just-identified model yielding better results under potential *weak instruments* (Angrist & Pishke, 2008), we also estimate the over-identify model using two extra instruments to check the robustness of our results. See Appendix.

[14] The coca leaves grown in rainforest and subtropical rainforest are called *yungas*. The optimal altitude is around 1000 to 2000 meter, with an average rainfall of 2000 mm, but it is possible to grow coca in altitudes around 700 to 2000 with an average rainfall of 1000 to 4200mm (Mejía & Rico, 2010; Plowman, 1985).

[15] In the Appendix we provide extra empirical evidence and descriptive statistics for our instruments.

4.2. Descriptive Statistics

Our purpose is to identify the impact of conflict on the decision to abandon/continue coffee and on the share of land allocated to coffee production. In table 2, we report the farm and household characteristics of growers of the entire sample, and divided by those that drop and did not drop out of coffee production in 2008 using characteristics from the CCG93/97 census. Results indicate that farmers who abandoned are systematically different from those who continued. The differences between the two groups are statistically significant at the 1% level for all variables. Coffee growers that abandoned coffee production by 2008 had a lower number of trees, a smaller percentage of the land plot allocated to coffee, had older trees and the density of trees was lower, yet the size of the overall land plot was larger. Municipal characteristics also differ: the quality of land in the municipality was slightly higher, the altitude was lower, the number of FNC's technicians was lower and the earthquake of 1999 affected more households. Although relative prices of coffee were slightly higher, coffee production in the municipality contracted. Attacks of armed groups and the presence of coca in the municipality are more frequent in municipalities where household opted-out of coffee production. The sub-sample with household characteristics for those that continued or abandoned coffee are slightly different. Coffee growers that continued coffee production had a larger percentage of male heads, with higher education levels, and had more household members in their productive years, which presumably could support coffee production.

[Table 2 goes about here]

Producers that continued coffee production apparently became more efficient between 1993 and 2008. Table 3 reports production variables for these growers. Although the percentage of land allocated to coffee production decreased from 63.5 to 60.6 percent, the number of trees increased by 17 percent and density by eight percent. The age of coffee trees shows that most farmers did not engage in renovation processes. Finally, the size of land plots decreased slightly. Presumably, coffee growers who continued absorbed some of the production loss those that opted out.

[Table 3 goes about here]

Municipal characteristics for non-coffee regions, regions that abandoned altogether coffee production, and regions that continued coffee production are reported in Table 4. In contrast to non-coffee regions, coffee regions are geographically located in areas with higher altitude and land with better quality. The average number of attacks of armed groups is slightly higher for coffee regions, but the difference is not statistically significant. The percentage of coca production in non-coffee productions is twice that of coffee regions. Municipalities that abandoned coffee production are located in regions with lower altitude, which shows that these regions were not the better suited for coffee production. The fall in prices may have pushed out coffee production in the less suited municipalities. Although coca production and dropping out of coffee are positively correlated, the causality is not clear. It may be the case that farmers relied on coca production after abandoning coffee cultivation or that farmers abandoned coffee production to cultivate coca. The following approach establishes a causal effect of coca cultivation on coffee production.

[Table 4 goes about here]

5. Empirical results

We find a significant impact of the risk of violence and the presence of illegal crops on the decision to continue coffee production and in the percentage of the farm allocated to coffee in 2008. Results are robust after dealing with endogeneity in the selection equation. In line with our theoretical model, we find that coffee growers are more likely to follow a corner allocation rule when they are exposed to high risk of violence and the presence of illegal crops. After relaxing the distributional assumption in the fully-parameterized Heckit, we obtain similar results.

5.1. The participation decision

Table 6 reports the results of the selection equation described in Eq. (9). For ease of interpretation, coefficient estimates are expressed as marginal effects. The first four columns show the Probit model specifications considered in our analysis[16]: *First,* we

[16] Following McCullogh and Vinod (2003), we provide a discussion and extra statistical evidence on the convergence for the non-linear Probit estimations. See the Appendix.

estimate a naive Probit; *second*, we instrument the Average Coca cultivation (in % of hectares) (1997-2008); *third*, we instrument Average military actions (1997-2008) (by 100 people); and *fourth*, we instrument both jointly. To assess the possibility of weak instruments, we report the Linear Probability Model –LPM– that provides more flexibility to test the validity of our instruments[17].

We estimate the LPM through Limited Information Maximum Likelihood –LIML. In addition to having the same large-sample distribution as the standard IV-OLS, LIML provides less biased estimators yielding more robust estimations in case of potentially weak instruments (Angrist & Pishke, 2008). Furthermore, even though diagnostic tests to detect weak instruments are analogous for the two estimation methods, they have different (smaller) critical values (Angrist & Pishke, 2008; Murray, 2006)[18]. In spite of the absence of a unique criterion to conclude the presence of weak instruments, we report a set of statistics that we consider informative: (i) over-identification test (Hansen J-statistics); (ii) rank test (Kleibergen-Paap rk LM); (iii) Wald F statistic for Weak instruments (Kleibergen-Paap rk Wald) and (iv) the weak-instrument-robust inference proposed by Anderson and Rubin based on a test of structural parameters that is robust to weak instruments (Murray, 2006). We also compute the exogeneity test for both Probit and LPM.

Table 5 shows the first stage results for the different model specifications. In general, instruments are statistically significant at the 1% level[19]. Instrument relevancy is confirmed by the under-identification tests, which shows that our instruments are not only relevant but also exogenous in the selection equation (see Notes in Table 6). Even though the Kleibergen-Paap rk Wald for PROBIT and LIML is not completely conclusive on the potential weakness of our instruments in all specifications, several elements strengthen their validity: (i) the magnitude of the

[17] Although LPM ignores the discreteness of the dependent variable, producing problems such as predictions above the unit circle and constant marginal effect (Gouriéroux, 1991; Maddala, 1983), it provides a good guide to which variables are statistically significant and, in particular, it allows to tackle extra problems that are difficult to solve in a non-linear model (Wooldridge, 2008)

[18] We also estimate the 2SLS yielding similar results as the LIML, which shows the consistency of the estimations (Angrist & Pishke, 2008). See the Appendix.

[19] Although the just-identified model may yield better results under potential *weak instruments* (Angrist & Pishke, 2008), we use two instruments per variable. Two elements strengthen this decision: (i) we found that results improve without affecting the exclusion restriction and relevancy; (ii) having two instruments allow us to have extra evidence about the relevancy (e.g. it is feasible to compute the over-identification test). Nevertheless, results for the just-identified specification are reported in the Appendix.

coefficients after instrumentation does not increase particularly strong; (ii) Weak-instrument-robust inference yields consistent standard errors and (iii) Except for initial specification for *Average military actions (1997-2008) (by 100 people)*, the F-static for excluded instruments is above 10.

[Table 5 goes about here]

The exclusion restrictions are statistically significant across the different specifications in the selection equation. The natural experiment as a result of the 1999 earthquake seems to have effect in both directions; an increase of one standard deviation in the mean of the percentage of people that lost their house decreases the probability of continuing coffee production by -0.04, holding other variables to their means[20]. However, the opposite is true when we consider people who suffered any personal damage: the coefficient is smaller but positive. These results allow us to identify participation separately from allocation.[21]

Tests for endogeneity provide evidence that the Average Coca Cultivation (in % of ha) (1997-2008) could be treated as exogenous if we consider it as the unique source of endogeneity ($\chi^2_{(1)} = 0.10$). The Average Military Actions (1997-2008) (by 100 people) has contradictory results when we test it using non-linear ($\chi^2_{(1)} = 2.85$) and LPM ($\chi^2_{(1)} = 5.90$) models; similar results occur when we test both variables jointly (Probit - $\chi^2_{(2)} = 2.93$. LPM - $\chi^2_{(2)} = 6.05$).

The correlation between the continuation of coffee cultivation and the mean of attacks or the percentage of coca cultivated is negative. Before considering potential endogeneity bias, an increase of one standard deviation in the mean of attacks and the percentage of coca cultivated decrease the probability of continuation by -0.2 and -0.01 percent respectively. Once we correct for endogeneity using our three different specifications, the magnitude of the coefficients changes. If we consider violence as the unique source of endogeneity (table 6, Column II), we find a similar magnitude

[20] $\frac{\Delta \Pr(y=1|\bar{x})}{\Delta x_k} = Pr\left(y = 1 \middle| \bar{x}, \bar{x}_k - \frac{s_k}{2}\right) - Pr\left(y = 1 \middle| \bar{x}, \bar{x}_k + \frac{s_k}{2}\right)$, where, s_k is the standard deviation.

[21] Even though there is no explicit way to test this identification restriction, we carry out an extra analysis similar to the over-identification restriction. See the Appendix.

for the marginal effect of illegal crops and an increase in the effect of violence to -0.60. Now, considering both variables as endogenous (table 6, Column III), increases the negative effect for both variables: for violence we have a negative parameter of -0.60 but for the illegal crops it is not significant (table 6, column IV). In general, the negative effect of violence is equivalent to moving from the mean of the population who lost their house in the 1999 earthquake to 99th percentile[22]. Other controls confirm that the likelihood of the continuation of coffee is lower for less productive farmers with larger land plots. Furthermore, the technical assistance provided by FNC seems to constitute a strong incentive to continue coffee production.

[Table 6 goes about here]

Table 7 reports the result for the selection equation using the sub-sample with household characteristics. Results are robust. Because the effect of the earthquake is higher for vulnerable households, after including household characteristics the magnitude of the effect of the exclusion restrictions (two consequences of the 1999 earthquake) decreased or become not significant. Instrument validations and endogeneity are analogous to the analysis presented above with the entire sample. In general, a one-standard deviation increase in the average area under coca cultivation (in % of ha) (1997-2008) yields a decrease in the probability of the continuation of coffee production of around -0.01 to -0.02. Regarding the Average Military Actions, an increase on one-standard deviation reduce the probability are around -0.02 and -0.03. Other controls have similar magnitude and sign as for the whole sample.

[Table 7 goes about here]

As we pointed out above, coffee growers who were exposed to high risks of violence and to illicit crops are more likely to abandon coffee production. Therefore, even though we could not identify the *subsistence* or *illegal* dropping out corner solution described by our theoretical model, results provide strong evidence on the existence of an alternative allocation rule as risk coping strategy against the risk of violence and illegal crops. Likewise, the negative effect of being exposed to the risk of violence is higher than to the presence of illicit crops.

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[22] $Pr\left(y=1\middle|\bar{x},\bar{x}_k-\frac{s_k}{2}\right)-Pr\left(y=1\middle|\bar{x},\bar{x}_k+\frac{s_k}{2}\right)\approx Pr\left(y=1\middle|\bar{x},x_{j,99}\right)-Pr\left(y=1\middle|\bar{x},\bar{x}_j\right)$, where $\bar{x}_k$ is our violence variable and $\bar{x}_j$ population affected by the earthquake.

5.2. The allocation decision

Abandoning coffee production is an extreme strategy households may adopt to mitigate the impact of shocks or to reap the short-term benefits of coca production. Farmers who continue coffee production may also change the percentage of land allocated to coffee production, leading to changes in coffee production. Table 8 reports the results for the allocation equation. Given the results from the selection equation, we use four different specifications: (i) OLS; (ii) Heckit estimator without any endogeneity correction in the selection equation (Heckit-I); (iii) Heckit estimator assuming that only the average military action (1997-2008) is the source of endogeneity bias in the selection equation (Heckit-II) and (iv) Heckit estimator instrumenting average military actions and average crop cultivation jointly (Heckit-III). We apply the same structure for the subsample with household characteristics.

A contraction in the percentage of the farm allocated to coffee is correlated with an increment in the percentage of coca cultivated in the municipality after correction for sample selectivity. For the entire sample, an increase of one standard deviation of the average military action (1997) is correlated with a drop of the percentage of land allocated to coffee of -0.002 in the Heckit-I and -0.02 in Heckit-II and -III. In the case of the average coca cultivation, a one-standard deviation increase is correlated with a decrease in the farm percentage allocated to coffee of -0.005 in Heckit-II and Heckit-III respectively. Once household characteristics are included, coefficients increase. An increase of one standard deviation in the average of military action (1997-2008) and in the mean of attacks is correlated with a drop of the percentage of the farm allocated to coffee of -0.007 and -0.02 standard deviations respectively in Heckit-I as well as Heckit-II.

Initial conditions from CCS93/97 have strong and consistent correlations with coffee in the allocation rule in 2008. Two facts are noteworthy: *first*, the plot size and the farm percentage allocated to coffee in CCS93/97 have the largest correlation among the controls included; *second*, a crop renovation process is suggested by the negative correlation of the average age of the coffee trees in CCS93/97. Presumably those coffee growers who continue to grow coffee become more efficient. While the size of the farm is negatively correlated with the percentage allocated to coffee, the density and the age of the crop are positively correlated.

[Table 8 goes about here]

The ability of farmers to devise strategies that minimize the costs of conflict may depend on initial assets, access to formal financial and insurance markets. Moreover, larger producers or formal landowners may face larger costs from producing illicit crops (i.e. loosing land property). Although the estimations control for asset ownership and other variables that are constant over time, we can expect changes in asset composition, access to credit and insurance markets from 1993/97 till 2008. Unfortunately, the CCS93/97 and SICA did not collect information to control for these variables. As access to credit, insurance and landownership is highly correlated with the size of land plots (Rosenzweig & Foster, 2010), we estimate both regressions for three subsamples based on the size of the land plot: (i) small producers (less than 5 hectares); (ii) medium producers (between 5 and 25 hectares); and large producers (more than 25 hectares). Table 9 reports the results for the probability of continuing coffee and for the allocation rule using the same specification as above.

Small producers living in regions with a large percentage of coca are more likely to drop out of coffee. An increase in one standard deviation of the percentage of coca reduces the probability of continuing by around -0.01 percent on average. Medium producers exposed to high average municipality coca cultivation are also more likely to abandon coffee. Once they decide to continue with coffee cultivation, they decrease the percentage of their farm allocated to it. A one-standard deviation increase in the percentage of coca reduces the probability of continuing by around -0.01 percent and reduces the percentage of land allocated to coffee by around -0.004 on average.

An intensification of armed group activities is correlated with a reduction of the probability of continuing coffee production for small, medium and large producers. In fact, the impact for small producers is higher than for others: an increment of one standard deviation in military actions is correlated with a decrease, on average, of -0.01 for small producers, -0.03 for medium producers and -0.06 for larger ones. The risk of violence does not have effect on the allocation rule once large producers decide to continue. By having access to financial markets and presumably owning a higher capital stock, larger farmers may recur more easily to coping strategies. A one-standard deviation increase in the average military actions (1997-2008) is correlated with a reduction of the farm percentage allocated to coffee in 2008 by around -0.02 and -0.03 for small and medium producers respectively.

[Table 9 goes about here]

5.3. Model validation

Our results and its underlying econometric assumptions have been tested for robustness as much as possible. Two main assumptions have to be checked: the exclusion restriction and the normality distribution assumption on observables and unobservables. The first assumption was tested through its empirical and statistical relevance: we showed that the natural experiment (the 1999 earthquake) had a significant effect in the selection mechanism.

The normality assumption on observables is tested analyzing the linear prediction in our selection equation and in the allocation equation, using the whole sample and the sub-sample with household characteristics. *First*, we found that for both samples the index is distributed roughly normally, with a slight negative skew. Results are confirmed using the non-parametric kernel regression where we found a normal shape for all specifications of the selection equation. *Second*, even though we have a peak in the right hand side of the distribution, we can identify a normal distribution shape in the linear prediction for the allocation equation using the different Heckit models described in Table 8.[23]

We use the semi-parametric sample selection estimator proposed by Ahn and Powell (1993) to test whether the normality assumption on unobservables could be restrictive. Table 10 reports results for the entire sample and for the sub-sample with household characteristics. In general, sign and magnitude of the parameters are consistent with the full-parametric approach; it suggests the consistency of the causal relationship between allocation rule, violent risk and illicit crops. For the entire sample, an increase of one standard deviation in the average military actions reduces the farm

[23] All parametric and non-parametric evidence is provided in the Appendix.

percentage allocated to coffee by 0.03 standard deviations. In contrast, in the sub-sample with household characteristics we do not find a significant correlation with violent risk. Other controls are also analogous to the parametric approach. We conclude that the assumption of normality of the unobservables in the model is not restrictive.

[Table 10 goes about here]

In summary, the evidence appears to be quite robust. As predicted by our theoretical model, coffee growers who are exposed to violent risk and to the presence of illicit crops are more likely to abandon coffee production. Moreover, once they decided to stay, the percentage of the farm allocated to coffee decreases in municipalities with illicit crops or with violent risk.

6. Conclusions.

The paper examines the effect of conflict and illicit crops on production decisions of coffee growers. Conflict may influence agricultural decisions through two channels. *First*, by destroying assets, deteriorating human capital, reducing the provision of public and private goods and increasing transactions costs, conflict has a direct impact on agricultural production. *Second*, conflict may change the incentives to participate in the production of illegal crops. The breakdown of the rule of law, the deliberate strategy of armed groups to promote illegal crop cultivation, and a decrease in the profits from legal agricultural production modify the returns of participating in legal versus illegal markets. We developed a simple theoretical framework whereby we formalize these mechanisms.

We test how both channels affect the production of an export crop using a unique panel dataset of Colombian coffee growers. Even though the institutional support provided by FNC kept coffee growers isolated from the Colombian conflict for many years, the coffee market crises, the increase of violence and the soaring of coca crops in Colombia in the late 20th century generated an unfavorable environment for coffee cultivation. We argue that this prompted farmers to abandon or reduce coffee production.

We estimate a sample selection model using Heckit estimator (Type II-Tobit). We address potential endogeneity bias in the selection equation for both violent risk and illegal crops. To delve into this, four different specifications in the selection equation were estimated, including three IV models. Instruments were validated through linear and non-linear approaches.

We found a significant impact of violent risk and of illegal crops on the decision to continue coffee production and on the farm percentage allocated to coffee in 2008. Results are robust after controlling for endogeneity in the selection equation. As predicted by our theoretical model, we found that coffee growers are more likely to follow a corner allocation rule when they are exposed to high violent risk and/or illegal crops. After relaxing distributional assumptions in the full-parameterized Heckit, we obtain similar results.

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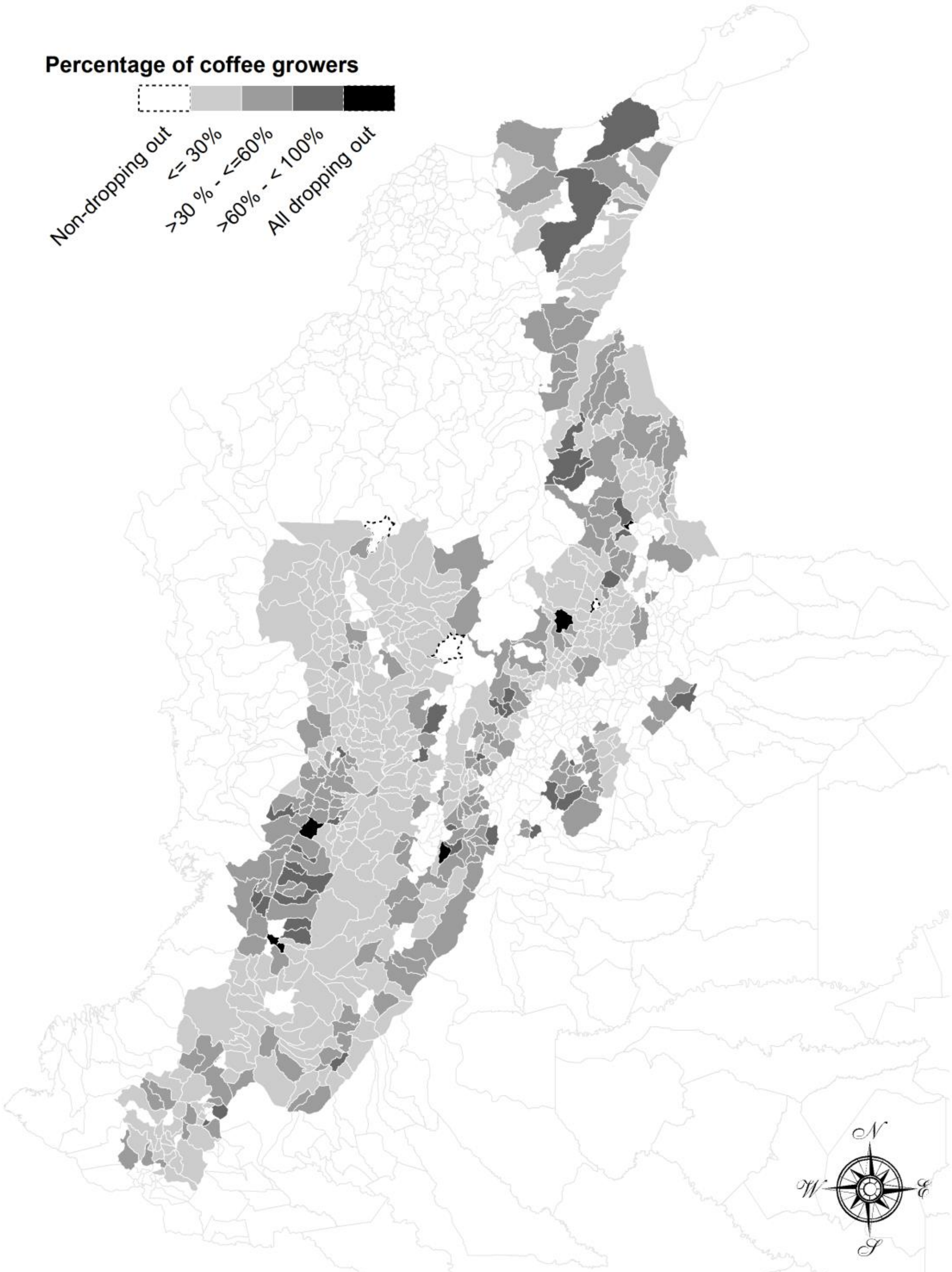
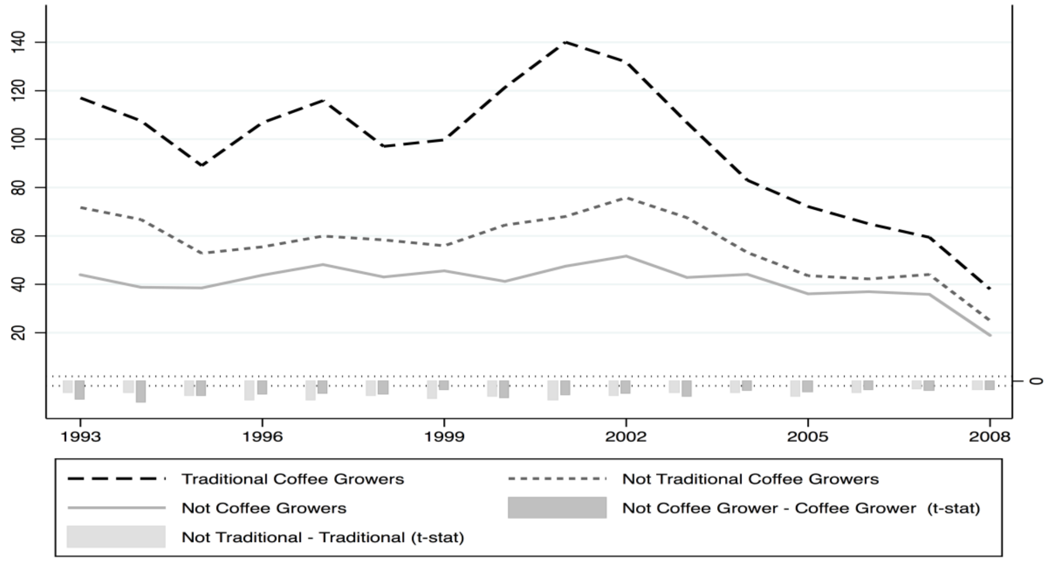
Map 1. Coffee production: coffee growers percentage that abandoned and continued coffee production between 1993 and 2008.



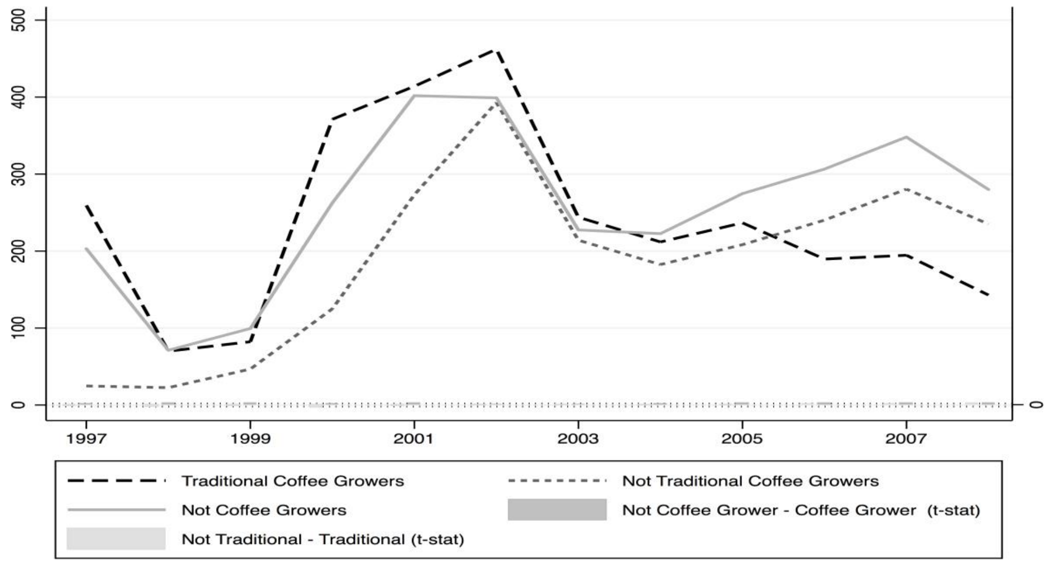
Notes – We define dropped-out coffee grower as the farmer with available information in the census data 1993/97 but without information in the Coffee Information System in 2005 (SICA - Spanish name). Data source: CCS93/97,SICA (2008).

Graph 1. Homicide rates (1993-2008): traditional coffee, non-traditional coffee and non-coffee municipalities.



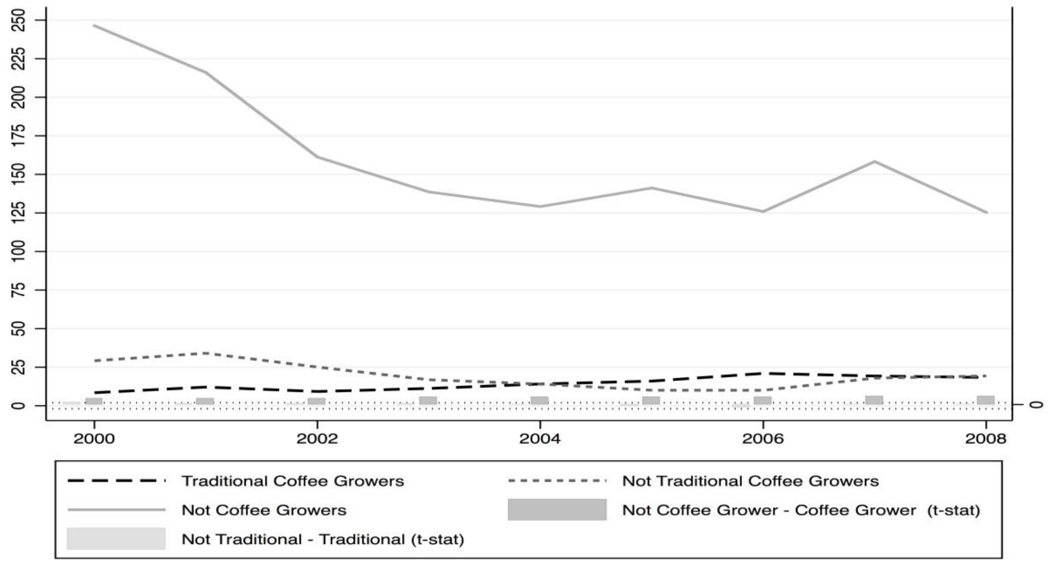
Notes – We consider all Colombian municipalities and we use the census information (CCS93/97) to classify the coffee growers municipalities. Regarding the classification between traditional and not traditional, historical coffee production information from 1970 was used. The double-sided t-test is reported with the 5% statistical significance level plotted on top. Data source: CCS93/97, CEDE (2012).

Graph 2. Forced displacement (1993-2008): traditional coffee, non-traditional coffee and non-coffee municipalities



Notes – We consider all Colombian municipalities and we use the census information (CCS93/97) to classify the coffee growers municipalities. Regarding the classification between traditional and not traditional, historical coffee production information from 1970 was used. The double-sided t-test is reported with the 5% statistical significance level plotted on top. Data source: CCS93/97, CEDE(2012).

Graph 3. Coca cultivation (in hectares): traditional coffee, non-traditional coffee and non-coffee municipalities



Notes – We consider all Colombian municipalities and we use the census information (CCS93/97) to classify the coffee growers municipalities. Regarding the classification between traditional and not traditional, historical coffee production information from 1970 was used. The double-sided t-test is reported with the 5% statistical significance level plotted on top. Data source: CCS93/97, SIMCI (2011).

Table 1. Feasible corners solutions by violent states.

Violent 'ex ante' state	s_t	z_t	n_t	
$\varphi_t = 0$	> 0	$\begin{cases} > 0 \\ \rightarrow 0 \; if \; \varepsilon_t \gg 0 \end{cases}$	$\rightarrow 0$	*Interior solution* ***Subsistence dropping out***
$\varphi_t = 1$	> 0	$\begin{cases} > 0 \\ \rightarrow 0 \; if \; \varepsilon_t \gg 0 \\ \rightarrow 0 \; if \; \varepsilon_t \gg 0 \end{cases}$	$\begin{cases} \rightarrow 0 \; if \; \lambda_t \gg 0 \\ > 0 \\ \rightarrow 0 \; if \; \lambda_t \gg 0 \end{cases}$	*Interior solution* ***Illegal dropping out*** ***Subsistence dropping out***

Table 2. Descriptive statistics by farms and households: entire sample, drop-out and not drop-out.

	Entire sample				Sub-sample with Household characteristics			
	Sample	**Not Drop-out**	**Drop-out**	**Sign.of diff.**	**Sample**	**Not Drop-out**	**Drop-out**	**Sign.of diff.**
Average military actions (1997-2008)	3.785	3.572	4.442	***	3.928	3.709	4.991	***
	[7.879]	[6.989]	[0.000]		[8.255]	[7.362]	[11.593]	
Average Coca cultivation [% of hectares] (1997-2008)	0.035	0.031	0.000	***	0.035	0.032	0.050	***
	[0.148]	[0.115]	[0.000]		[0.139]	[0.109]	[0.233]	
Farm Percentage cultivated on coffee (1997)	0.635	0.636	0.632	***	0.520	0.528	0.479	***
	[0.366]	[0.360]	[0.000]		[0.351]	[0.348]	[0.364]	
Coffee trees per farm (1997)	5427.975	5619.316	4839.973	***	4923.601	5086.098	4135.080	***
	[16148.112]	[15708.364]	[0.000]		[7547.431]	[7543.578]	[7516.458]	
Average age trees per farm (1997)	10.870	10.525	11.930	***	11.549	11.257	12.966	***
	[10.409]	[10.060]	[0.000]		[10.378]	[10.120]	[11.446]	
Coffee crop density [treesxhta] (1997)	4151.139	4192.366	4024.447	***	3997.928	4038.861	3799.297	***
	[1508.059]	[1484.169]	[0.000]		[1422.628]	[1407.490]	[1477.912]	
Farm size (ha) (1997)	4.613	4.334	5.471	***	5.318	5.082	6.464	***
	[15.080]	[12.622]	[0.000]		[11.894]	[10.534]	[16.969]	
Land quality (UAF)	19.017	19.254	18.289	***	19.168	19.286	18.594	***
	[9.404]	[9.498]	[0.000]		[9.399]	[9.384]	[9.451]	
Altitude	1431.139	1447.122	1382.022	***	1413.813	1427.587	1346.976	***
	[499.859]	[498.365]	[0.000]		[502.132]	[498.786]	[512.838]	
Affected by earthquake 1999 (yes=1)	0.034	0.031	0.044	***	0.028	0.025	0.041	***
	[0.182]	[0.174]	[0.000]		[0.165]	[0.157]	[0.199]	
FNC technicians	2.300	2.339	2.180	***	2.248	2.289	2.051	***
	[1.866]	[1.862]	[0.000]		[1.878]	[1.881]	[1.851]	
Change on cultivated area coffee municipal	-0.146	-0.122	-0.217	***	-0.152	-0.130	-0.257	***
	[0.185]	[0.168]	[0.000]		[0.188]	[0.171]	[0.229]	
Price on other agricultural products (mean)	0.304	0.304	0.305	***	0.305	0.305	0.307	***
	[0.081]	[0.080]	[0.000]		[0.088]	[0.086]	[0.097]	
Price on other agricultural products (Std. desv.)	0.039	0.040	0.039	***	0.039	0.039	0.038	***
	[0.020]	[0.021]	[0.018]		[0.021]	[0.022]	[0.018]	
Household head age (1997)					51.459	51.179	52.818	***
					[14.581]	[14.374]	[15.478]	
Male household head (yes=1)					0.805	0.812	0.774	***
					[0.396]	[0.391]	[0.418]	
Household head schooling (1997) (years)					1.785	1.789	1.768	***
					[0.532]	[0.520]	[0.584]	
Household members between 15-65 years old (1997)					2.784	2.825	2.586	***
					[1.579]	[1.581]	[1.554]	
Observations	663536	500627	162909		273917	227114	46803	

Notes –Standard errors in brackets. * Significant at 10%, ** significant at 5%, and *** significant at 1%. Two-side mean test significance reported. Land quality is measured as the minimum size required to earn a minimum wage; this minimum size (UAF by its Spanish acronym) is defined by the Colombian Government. For other agricultural products we include a substitution crops . Data source: CCS93/97,SICA (2008) and CEDE [2012].

Table 3. Descriptive statistics: production between 1993 and 2008

	Sample	1997	2008	Significance
Coffee trees per farm	5846.490	5427.975	6401.194	***
	[16510.374]	[16148.112]	[16962.724]	
Cultivated coffee area (ha)	1.340	1.302	1.390	***
	[3.057]	[3.120]	[2.971]	
Average age crop per farm	12.506	10.870	14.674	***
	[11.139]	[10.409]	[11.690]	
Coffee crop density (treesxhta)	4307.630	4151.139	4515.044	***
	[1507.173]	[1508.059]	[1480.728]	
Farm size (ha)	4.518	4.613	4.391	***
	[13.742]	[15.080]	[11.733]	
Farm Percentage cultivated on coffee	0.622	0.635	0.606	***
	[0.358]	[0.366]	[0.347]	
Observations	1164163	663536	500627	

Notes – Standard errors in brackets. * Significant at 10%, ** significant at 5%, and *** significant at 1%. Two-side mean test significance reported. Data source: CCS93/97 and SICA [2008].

Table 4. Descriptive statistics at the municipality level

	All municipalities	Coffee growers	Not Coffee growers	Sign.of diff.	Coffee Growers not Drop-out	Coffee Growers Drop-out	Sign.of diff.
Altitude							
Mean	1183.330	1343.827	1006.241	***	1350.204	844.571	*
Standard deviation	(1162.544)	(605.260)	(1543.217)		(603.858)	(536.083)	
Observation	1058	555	503		548	7	
Land quality (UAF)							
Mean	22.718	20.067	26.279	***	20.103	16.824	
Standard deviation	(17.665)	(12.277)	(22.531)		(12.318)	(7.892)	
Observation	785	450	335		445	5	
Average Coca cultivation (% ha) (1997-2008)							
Mean	0.045	0.020	0.072	***	0.020	0.013	
Standard deviation	(0.240)	(0.085)	(0.328)		(0.086)	(0.023)	
Observation	1102	559	543		552	7	
Average military actions (1997-2008)							
Mean	1.054	1.194	0.911	*	1.208	0.048	
Standard deviation	(1.848)	(1.833)	(1.853)		(1.840)	(0.087)	
Observation	1103	559	544		552	7	

Notes – Standard errors in brackets. * Significant at 10%, ** significant at 5%, and *** significant at 1%. Two-side mean test significance reported. Data source: CCS93/97 and SICA (2008). Whole municipalities include all the Colombian villages. Municipalities coffee growers are composed by all the villages with available information in either CCS93/97 and/or SICA (2008). Coffee growers drop-out are all the municipalities with information at CCS93/97 and without any information at SICA (2008). Data source: CCS93/97 and SICA (2008).

Table 5: Just-identified First stage

	Average Coca cultivation (% ha) (1997-2008)				*Average military actions (1997-2008) (by 100 people)*			
	I	II	III	IV	I	II	III	IV
Hectares covered by rainforest (by 100000 ha)	0.326***	0.331***	0.329***	0.334***			0.042*	0.034
	[0.106]	[0.096]	[0.109]	[0.099]			[0.021]	[0.024]
Former territories occupied by Spanish (1510 -1561) with land conflict in 1918-1931.			0.021	0.018	0.107***	0.113***	0.108***	0.114***
			[0.024]	[0.021]	[0.026]	[0.028]	[0.027]	[0.028]
Household characteristics	No	Yes	No	Yes	No	Yes	No	Yes
Market controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Production and Institution	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Observations	663536	273917	663536	273917	663536	273917	663536	273917
R2	0.119	0.118	0.119	0.119	0.297	0.315	0.299	0.316
F-statistic	11.536	10.533	11.230	10.515	6.965	6.420	12.330	9.755

Notes - Standard errors in brackets, clustered at the municipality level. * significant at 10%, ** significant at 5%, and *** significant at 1%. Estimation method by OLS. Dependent variable columns I to IV: Average Coca cultivation (% ha) (1997-2008). For columns V to VIII: Average military actions (1997-2008) (by 100 people). Coffee committee-specific, coffee-natural regions and CCS93/97 year-carried out fixed effects included. Farm characteristics 1998 refers to the coffee production information from CCS93/97, it includes: Cultivated coffee area (ha), Average age crop per farm, Coffee crop density (treesxhta), Farm size (ha) and Farm Percentage cultivated on coffee. Market's controls: mean for the price on other agricultural products. Production and Institution's controls: FNC technicians and Change on cultivated area coffee municipal. Municipality's controls: Land quality [UAF] and Altitude. Household characteristics: Household head age, Male household head [yes=1], Household head schooling [1997] (years) and Household members between 15-65 years old [1997] . Data source: CCS93/97,SICA [2008] and CEDE [2012].

Table 6. Selection equation for entire sample: probability of continuing coffee production.

	I	II	III	IV	V	VI	VII	VIII
	Probit	IV-Probit	IV-Probit	IV-Probit	LPM	IV-LIML	IV-LIML	IV-LIML
Average Coca cultivation (% ha) (1997-2008)	-0.062***	-0.097	-0.063***	-0.069	-0.075***	-0.092	-0.075***	-0.062
	[0.012]	[0.106]	[0.012]	[0.108]	[0.013]	[0.106]	[0.012]	[0.112]
Average military actions (1997-2008) (by 100 people)	-0.244***	-0.245***	-0.602***	-0.602***	-0.266***	-0.266***	-0.653***	-0.654***
	[0.066]	[0.065]	[0.198]	[0.194]	[0.080]	[0.080]	[0.220]	[0.221]
Farm Percentage cultivated on coffee (1997)	-0.024***	-0.025***	-0.026***	-0.026***	-0.024***	-0.025***	-0.025***	-0.025***
	[0.008]	[0.009]	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]	[0.009]
Farm size (ha) (1997)	-0.060***	-0.060***	-0.061***	-0.061***	-0.065***	-0.065***	-0.066***	-0.066***
	[0.009]	[0.009]	[0.010]	[0.011]	[0.010]	[0.010]	[0.011]	[0.011]
Coffee crop density (treesxhta) (1997)	0.005**	0.005**	0.004**	0.004**	0.005**	0.005**	0.004**	0.004**
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Average age crop per farm (1997)	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
FNC technicians	0.009***	0.009**	0.012***	0.012***	0.010***	0.010**	0.013***	0.013***
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Change on cultivated area coffee municipal	0.902***	0.855***	0.939***	0.931***	1.005***	0.981***	1.045***	1.063***
	[0.236]	[0.275]	[0.235]	[0.276]	[0.260]	[0.297]	[0.259]	[0.299]
Traditional Coffee department (yes=1)	0.178**	0.179**	0.128*	0.128*	0.196	0.197	0.134	0.133
	[0.084]	[0.084]	[0.066]	[0.066]	[0.131]	[0.131]	[0.095]	[0.096]
Population who lost their house in the 1999 earthquake (% total population)	-0.018***	-0.018***	-0.017***	-0.017***	-0.020***	-0.020***	-0.019***	-0.019***
	[0.006]	[0.006]	[0.006]	[0.006]	[0.007]	[0.007]	[0.007]	[0.007]
Population who suffered any personal damage in the 1999 earthquake (% total population)	0.008**	0.008**	0.008***	0.008**	0.009**	0.009**	0.009***	0.009***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.004]	[0.004]	[0.003]	[0.003]
Municipality and market controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	No	No	No	No	No	No	No	No
Observations	663536	663536	663536	663536	663536	663536	663536	663536
Log-LL	-356216.2	-312196.1	506847.0	551820.9	-367654.8	-367683.1	-369012.1	-369034.9

Notes – Standard errors in brackets, clustered at the municipality level. * significant at 10%, ** significant at 5%, and *** significant at 1%. Dependent variable: stay of coffee crop between 1997 - 2008 (yes=1). Conditional marginal effects at mean reported in the Probit estimations. Columns II , III and IV respectively show the IV-Probit instrumenting Average Coca cultivation (% ha) (1997-2008), Average military actions (1997-2008) (by 100 people) and both. Same for columns VI, VII and VIII using lineal specification. Coffee committee-specific, coffee-natural regions and CCS93/97 year-carried out fixed effects included. All estimations include constant. Municipality's controls: Land quality [UAF], Altitude and Distance to the regional capital. Market's controls: mean of the price on other agricultural products. Wald test of exogeneity (Chi2(1)) for Column II 0.10 (p-value= 0.74), for III 2.85 (p-value= 0.09), for IV 1.68 (p-value= 0.43) . The rank or under-identification test (LM statistics), for the same for column VI, VII and VIII are: 2.82 (p-value=0.09), 7.96 (p-value=0.00), 2.93 (p-value=0.08), respectively. The Kleibergen-Paap rk Wald F statistic for Weak instruments for columns VI, VII and VIII are: 9.53 (10% max LIML size =8.68), 16.6 (10% max LIML size =8.6), 5.04 (10% max LIML size =4.72). The Endogeneity test (chi2) for Average Coca cultivation (% ha) (1997-2008) using column VI 0.02 (p-value= 0.87), for Average military actions (1997-2008) (by 100 people) using column VII 5.90 (p-value=0.01), joint test from column VIII 6.05 (p-value=0.04). All results are consistent with Weak-instrument-robust inference proposed by Anderson and Rubin (2006). Data source: CCS93/97,SICA [2008] and CEDE [2012].

Table 7. Selection equation for subsample with household information: probability of staying coffee production.

	I Probit	II IV-Probit	III IV-Probit	IV IV-Probit	V LPM	VI IV-LIML	VII IV-LIML	VIII IV-LIML
Average Coca cultivation (% ha) (1997-2008)	-0.055***	-0.135	-0.055***	-0.115	-0.080***	-0.128	-0.080***	-0.106
	[0.014]	[0.102]	[0.013]	[0.085]	[0.015]	[0.102]	[0.015]	[0.109]
Average military actions (1997-2008) (by 100 people)	-0.177***	-0.178***	-0.513***	-0.509***	-0.213**	-0.213**	-0.627***	-0.625***
	[0.061]	[0.060]	[0.178]	[0.182]	[0.095]	[0.094]	[0.219]	[0.219]
Farm Percentage cultivated on coffee (1997)	0.064***	0.062***	0.064***	0.062***	0.064***	0.062***	0.064***	0.063***
	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]	[0.009]	[0.008]	[0.009]
Farm size (ha) (1997)	-0.033**	-0.032**	-0.036***	-0.035***	-0.038**	-0.037**	-0.042**	-0.042**
	[0.013]	[0.013]	[0.013]	[0.014]	[0.017]	[0.018]	[0.017]	[0.018]
Coffee crop density (treesxhta) (1997)	0.006***	0.007***	0.006***	0.006***	0.006***	0.006***	0.005***	0.005***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Average age crop per farm (1997)	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
FNC technicians	0.007**	0.007**	0.010***	0.010***	0.007**	0.007**	0.010***	0.011***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.004]	[0.004]
Change on cultivated area coffee municipal	0.845***	0.746**	0.886***	0.811***	1.082***	1.022***	1.130***	1.098***
	[0.278]	[0.298]	[0.280]	[0.301]	[0.335]	[0.353]	[0.334]	[0.351]
Traditional Coffee department (yes=1)	0.128*	0.131*	0.091*	0.094*	-0.497	0.130	0.071	0.073
	[0.072]	[0.072]	[0.053]	[0.053]	[0.871]	[0.158]	[0.109]	[0.110]
Population who lost their house in the 1999 earthquake (% total population)	-0.009*	-0.008	-0.008	-0.007	-0.011	-0.011	-0.009	-0.009
	[0.006]	[0.006]	[0.005]	[0.005]	[0.007]	[0.007]	[0.007]	[0.007]
Population who suffered any personal damage in the 1999 earthquake (% total population)	0.004*	0.004	0.004	0.004	0.006*	0.005	0.005*	0.005
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Municipality and market controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	No	No	No	No	No	No	No	No
Observations	273917	273917	273917	273917	273917	273917	273917	273917
Log-LL	-117818.7	-75195.9	229065.6	271946.3	-112687.9	-112792.4	-113605.7	-113629.3

Notes – Standard errors in brackets, clustered at the municipality level. * significant at 10%, ** significant at 5%, and *** significant at 1%. Dependent variable: stay of coffee crop between 1997 - 2008 (yes=1). Conditional marginal effects at mean reported in the Probit estimations. Columns II , III and IV respectively show the IV-Probit instrumenting Average Coca cultivation (% ha) (1997-2008), Average military actions (1997-2008) (by 100 people) and both. Same for columns VI, VII and VIII using lineal specification. Coffee committee-specific, coffee-natural regions and CCS93/97 year-carried out fixed effects included. All estimations include constant. Municipality's controls: Land quality [UAF], Altitude and Distance to the regional capital. Market's controls: mean and standard deviation of the price on other agricultural products. Wald test of exogeneity (Chi2(1)) for Column II 0.61 (p-value= 0.43), for III 3.25 (p-value= 0.07), for IV 2.19 (p-value= 0.33) . Under-identification test (LM statistics), for) for column VI, VII and VIII are: 3.11 (p-value=0.07) , 7.96 (p-value=0.00), 3.19 (p-value=0.07). The Kleibergen-Paap rk Wald F statistic for Weak instruments for columns VI, VII and VIII are: 11.86 (10% max LIML size =8.68), 16.15 (10% max LIML size =8.68), 6.19 (10% max LIML size =4.72). The Endogeneity test (chi2) for Average Coca cultivation (% ha) (1997-2008) using column VI 0.22 (p-value= 0.63), for Average military actions (1997-2008) (by 100 people) using column VII 7.00 (p-value=0.00) , joint test from column VIII 7.01 (p-value=0.02). All results are consistent with Weak-instrument-robust inference proposed by Anderson and Rubin (2006) .Data source: CCS93/97,SICA [2008] and CEDE [2012].

Table 8. Allocation equation: Farm Percentage cultivated on coffee in 2008.

	Whole sample				*Sub-sample with Household characteristics*			
	OLS	Heckit - I	Heckit - II	Heckit - III	OLS	Heckit - I	Heckit - II	Heckit - III
Average Coca cultivation (% ha) (1997-2008)	-0.005	-0.017	-0.030**	-0.037**	-0.009	-0.049***	-0.048***	-0.083***
	[0.011]	[0.016]	[0.014]	[0.015]	[0.015]	[0.015]	[0.013]	[0.027]
Average military actions (1997-2008) (by 100 people)	-0.046	-0.083*	-0.272***	-0.284***	-0.015	-0.108**	-0.354***	-0.096***
	[0.031]	[0.048]	[0.090]	[0.090]	[0.030]	[0.043]	[0.069]	[0.037]
Farm Percentage cultivated on coffee (1997)	0.739***	0.736***	0.731***	0.731***	0.742***	0.771***	0.771***	0.749***
	[0.010]	[0.010]	[0.010]	[0.010]	[0.009]	[0.011]	[0.010]	[0.009]
Farm size (ha) (1997)	0.437***	0.427***	0.416***	0.414***	0.523***	0.504***	0.501***	0.518***
	[0.050]	[0.050]	[0.050]	[0.050]	[0.083]	[0.083]	[0.083]	[0.083]
Coffee crop density (treesxhta) (1997)	0.001**	0.002**	0.003***	0.003***	0.003***	0.006***	0.006***	0.004***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Average age crop per farm (1997)	-0.001***	-0.001***	-0.001***	-0.001***	-0.000	-0.000***	-0.001***	-0.000*
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Farm size (ha) (2008)	-0.658***	-0.658***	-0.658***	-0.658***	-0.822***	-0.820***	-0.820***	-0.820***
	[0.057]	[0.057]	[0.057]	[0.057]	[0.086]	[0.086]	[0.086]	[0.086]
Coffee crop density (treesxhta) (2008)	0.002**	0.002**	0.002**	0.002*	-0.000	-0.000	-0.001	-0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Average age crop per farm (2008)	0.001***	0.001***	0.001***	0.001***	0.000*	0.000**	0.000**	0.000*
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
FNC technicians	-0.000	0.001	0.004*	0.004**	-0.000	0.003**	0.005***	0.001
	[0.001]	[0.002]	[0.002]	[0.002]	[0.001]	[0.001]	[0.001]	[0.001]
Change on cultivated area coffee municipal	0.074	0.210	0.382***	0.397***	0.098	0.593***	0.626***	0.225*
	[0.094]	[0.157]	[0.144]	[0.143]	[0.119]	[0.177]	[0.151]	[0.122]
Traditional Coffee department (yes=1)	0.004	-0.056	-0.253	-0.268	0.093	-0.139	-0.301**	0.002
	[0.134]	[0.150]	[0.171]	[0.171]	[0.109]	[0.129]	[0.136]	[0.111]
λ		0.093	0.203**	0.215***		0.308***	0.315***	0.079***
		[0.097]	[0.081]	[0.081]		[0.079]	[0.060]	[0.025]
Municipality and market controls	No	Yes	No	Yes	No	Yes	No	Yes
Household characteristics	500627	500627	500627	500627	227114	227114	227114	227114
Observations	0.669	0.669	0.669	0.669	0.689	0.690	0.690	0.690
R-square	-0.005	-0.017	-0.030**	-0.037**	-0.009	-0.049***	-0.048***	-0.083***

Notes – Standard errors in brackets, clustered at the municipality level. * significant at 10%, ** significant at 5%, and *** significant at 1%. The table presents results for different sample selection correction the Heckit – I assumes a selection equation without endogeneity, Heckit – II assumes a selection equation with Average military actions (1997-2008) endogenous and Heckit – III assumes a selection equation with Average military actions (1997-2008) and Average Coca cultivation (% ha) (1997-2008) endogenous. The parameter λ represents the Inverse Mill Ration form the different selection equation specifications. Coffee committee-specific, coffee-natural regions and CCS93/97 year-carried out fixed effects included. Market's controls: mean for the price on other agricultural products. Municipality's controls: Land quality [UAF] and Altitude. Household characteristics: Household head age, Male household head [yes=1], Household head schooling [1997] (years) and Household members between 15-65 years old [1997]. Data source: CCS93/97,SICA [2008] and CEDE [2012].

Table 9. Allocation equation for small, medium and large producers: Farm Percentage cultivated on coffee in 2008.

	Small (<= 5 ha)				*Medium (> 5 - <= 25 ha)*				*Large (>25ha)*		
	OLS	Heckit - I	Heckit - II	Heckit – III	OLS	Heckit - I	Heckit - II	Heckit - III	OLS	Heckit - I	Heckit - II
					Allocation equation						
Average Coca cultivation (% ha) (1997-2008)	-0.006	-0.007	-0.021*	-0.010	-0.003	-0.067***	-0.067***	-0.213***	-0.019	-0.022	-0.022
	[0.009]	[0.012]	[0.011]	[0.009]	[0.027]	[0.025]	[0.025]	[0.046]	[0.018]	[0.019]	[0.019]
Average military actions (1997-2008) (by 100 people)	-0.059	-0.062	-0.210***	-0.197***	-0.055	-0.250***	-0.326***	-0.285***	-0.006	-0.026	-0.027
	[0.040]	[0.044]	[0.075]	[0.076]	[0.035]	[0.059]	[0.072]	[0.058]	[0.020]	[0.054]	[0.054]
λ		0.009	0.128**	0.116*		0.322***	0.329***	0.290***		0.028	0.028
		[0.068]	[0.063]	[0.063]		[0.078]	[0.074]	[0.057]		[0.071]	[0.070]
Observations	398908	398908	398908	398908	86983	86983	86983	86983	14736	14736	14736
					Selection equation						
Average Coca cultivation (% ha) (1997-2008)		-0.056***	-0.057***	-0.018		-0.103**	-0.102**	-0.117		-0.102	-0.101
		[0.011]	[0.011]	[0.128]		[0.049]	[0.048]	[0.095]		[0.079]	[0.081]
Average military actions (1997-2008) (by 100 people)		-0.173***	-0.632**	-0.634***		-0.348***	-0.467***	-0.445***		-0.462***	-0.470***
		[0.043]	[0.270]	[0.233]		[0.078]	[0.178]	[0.169]		[0.104]	[0.156]
Population who lost their house in the 1999 earthquake (% total population)		-0.017**	-0.015**	-0.015**		-0.011*	-0.011*	-0.011*		-0.013*	-0.013*
		[0.008]	[0.007]	[0.008]		[0.006]	[0.006]	[0.006]		[0.007]	[0.007]
Population who suffered any personal damage in the 1999 earthquake (% total population)		0.008**	0.007**	0.007*		0.004	0.004	0.004		0.003	0.003
		[0.004]	[0.003]	[0.004]		[0.003]	[0.003]	[0.003]		[0.004]	[0.004]
Observations		528806	528806	528806		112898	112898	112898		21832	21832
Farm characteristics 1998	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Farm characteristics 2008	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	No	No	No	No	No	No	No	No	No	No	No

Notes –Standard errors in brackets, clustered at the municipality level. * significant at 10%, ** significant at 5%, and *** significant at 1%. Dependent variable in the upper panel: Farm Percentage cultivated on coffee in 2008. Dependent variable in the bottom panel:stay of coffee crop between 1997 - 2008 (yes=1)**.** Conditional marginal effects at mean reported in the Probit estimations. The table presents results for different sample selection correction the Heckit – I assumes a selection equation without endogeneity, Heckit – II assumes a selection equation with Average military actions (1997-2008) endogenous and Heckit – III assumes a selection equation with Average military actions (1997-2008) and Average Coca cultivation (% ha) (1997-2008) endogenous. Because limited information, the Heckit-III for Large producer the model did not converge. Coffee committee-specific, coffee-natural regions and CCS93/97 year-carried out fixed effects included. Farm characteristics 1998 refers to the coffee production information from CCS93/97, it includes: Cultivated coffee area (ha), Average age crop per farm, Coffee crop density (treesxhta), Farm size (ha) and Farm Percentage cultivated on coffee. Market's controls: mean for the price on other agricultural products. Production and Institution's controls: FNC technicians and Change on cultivated area coffee municipal. Municipality's controls: Land quality [UAF] and Altitude. Household characteristics: Household head age, Male household head [yes=1], Household head schooling [1997] (years) and Household members between 15-65 years old [1997] Data source: CCS93/97,SICA [2008] and CEDE [2012].

Table 10. Semi-parametric estimation for sample selection bias: Farm Percentage cultivated on coffee in 2008.

	Whole sample			Household characteristics subsample		
	I	II	III	IV	V	VI
Average Coca cultivation (% ha) (1997-2008)	-0.031*	-0.003	0.002	-0.069**	-0.011	-0.005
	[0.017]	[0.004]	[0.003]	[0.030]	[0.007]	[0.006]
Average military actions (1997-2008) (by 100 people)	-0.099**	-0.030***	-0.035***	0.010	0.012	0.002
	[0.039]	[0.011]	[0.011]	[0.048]	[0.010]	[0.012]
Farm Percentage cultivated on coffee (1997)		0.749***	0.745***		0.753***	0.749***
		[0.005]	[0.005]		[0.005]	[0.005]
Farm size (ha) (1997)		0.436***	0.435***		0.527***	0.525***
		[0.033]	[0.033]		[0.059]	[0.059]
Coffee crop density (treesxhta) (1997)		0.003***	0.002***		0.004***	0.003***
		[0.000]	[0.000]		[0.001]	[0.001]
Average age crop per farm (1997)		-0.001***	-0.001***		-0.000	0.000
		[0.000]	[0.000]		[0.000]	[0.000]
Farm size (ha) (2008)		-0.656***	-0.654***		-0.819***	-0.821***
		[0.036]	[0.036]		[0.058]	[0.058]
Coffee crop density (treesxhta) (2008)		0.001**	0.002***		-0.000	0.001
		[0.001]	[0.001]		[0.001]	[0.001]
Average age crop per farm (2008)		0.001***	0.001***		0.000	0.000*
		[0.000]	[0.000]		[0.000]	[0.000]
FNC technicians			0.000			0.000
			[0.001]			[0.001]
Change on cultivated area coffee municipal			0.071*			0.072
			[0.043]			[0.050]
Traditional Coffee department (yes=1)			0.034***			0.029***
			[0.001]			[0.002]
Household characteristics	No	No	No	Yes	Yes	Yes
Municipality and market controls	No	No	Yes	No	No	Yes
Observations	500627	500627	500627	227114	227114	227114
R2	0.055	0.663	0.664	0.068	0.685	0.686
F-statistic	52.1	2728.3	3098.2	108.817	2597.125	2753.277

Notes –Standard errors in brackets, clustered at the municipality level. * significant at 10%, ** significant at 5%, and *** significant at 1%. Dependent variable: Farm Percentage cultivated on coffee in 2008. Semi-parametric estimation method proposed by Ahn and Powel (1993). Non-parametric Kernel regressions using Epanechnikov kernel function with a Bandwidth 0.05. We include the Population who lost their house in the 1999 earthquake (% total population) and Population who suffered any personal damage in the 1999 earthquake (% total population) as exclusion restriction for the non-parametric kernel regression. Coffee committee-specific, coffee-natural regions and CCS93/97 year-carried out fixed effects included. Coffee committee-specific and CCS93/97 year-carried out fixed effects included. Market's controls: mean for the price on other agricultural products. Municipality's controls: Land quality [UAF] and Altitude. Household characteristics: Household head age, Male household head [yes=1], Household head schooling [1997] (years) and Household members between 15-65 years old [1997]. Data source: CCS93/97,SICA [2008] and CEDE [2012].